PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Ian BENNETT

Art Unit: 1723

Application No: 10/620,484

Examiner:

Filed: July 15, 2003

For: ROTARY MACHINE

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Sir:

This application claims priority of United Kingdom Patent Application No. 0216781.5 filed July 19, 2002. A certified copy of the United Kingdom patent application is transmitted herewith in order to complete the claim for priority.

Respectfully submitted,

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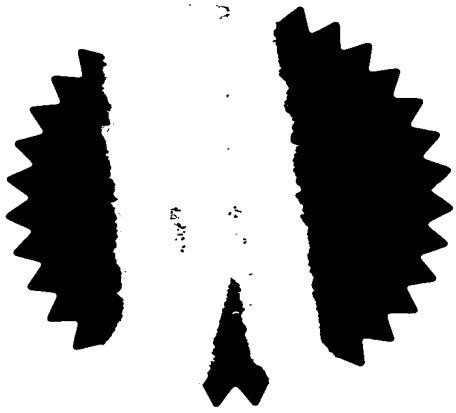

Signed

Dated 23 September 2003

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Patent 1977
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19JUL02 E734528-2 D01607
P01/7700 0.00-0216781.5

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1. Your reference

P/6768

2. Patent application number
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0216781.5

19 JUL 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Corac Group PLC
Brunel Science Park
Kingston Lane
Uxbridge
Middlesex UB8 3PQ

Patents ADP number *(if you know it)*

8137085001

If the applicant is a corporate body, give the country/state of its incorporation

a British company

4. Title of the invention

Rotary machine

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

A. Messulam & Co. Ltd
43-45, High Road
Bushey Heath
Herts WD23 1EE

Patents ADP number *(if you know it)*

07636210001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
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Description	5
Claim *(s)*	1
Abstract	1
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Any other documents *(please specify)*	

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Signature: A. Messulam — Date: 18 July, 2002

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ROTARY MACHINE

The present invention relates to a rotary machine, which term is used herein to refer to a compressor or a turbine that is made up of a rotor and a stator, carrying rotating and stationary rows of blades, respectively.

Rotary machines have been used as compressors to produce supplies of compressed gas in a wide variety of industrial applications. In most such applications, the rotary machines are only used to pump clean gas and accordingly there is no risk of damage to the machines from impurities in the intake gas.

There are however applications where it is impossible to avoid droplets and solid particles in the intake gas. One such application is in a downhole compressor that has been proposed for use in the oil and gas industry to help extract gas from a well and thereby extend the well's productive life. In this application, a compressor is lowered into a bore hole and operated to pump gas out of the well. As in this case the compressor acts to extract gas taken directly from a well, it is inevitable that it will carry some impurities in the form of liquid droplets and solid particles.

The reliability of a compressor in such an application is paramount, as it is not commercially viable to stop production from a well so that the downhole compressor can be recovered for servicing at regular intervals. On the contrary, it is desirable to be able to construct the compressor so that its expected life is comparable with that of the well.

The present invention thus seeks to provide a rotary machine that is tolerant to liquid droplets and particles in the intake gas, such impurities being managed in a manner

such as not to impair the reliability of the machine by damaging the bearings and such as not to reduce its expected life by causing wear to the blade rows.

In accordance with the present invention, there is provided a rotary machine having blade rows that impart a high swirl component to gases flowing through the machine so that the denser liquid fraction is deflected radially outwards by centripetal action onto the inner casing wall of the stator of the machine and wherein a surface is provided on the inner wall of the stator of the machine along which the impurities separated by centripetal action from the gas flow are guided to flow from the gas intake side of the machine to the gas outlet side, the surface being radially stepped in such a manner as to resist reverse flow of the impurities back towards the gas intake side of the machine on account of any differential gas pressure between the intake and outlet sides of the machine.

The guide surface is preferably formed by a stepped groove in the inner wall of the stator that only extends around part of the circumference of the stator. It is however alternatively possible for the entire inner surface to be constructed as a stepped surface being formed of a series of near conical sections that are separated from one another by sharp radial shoulder that prevent reverse gas and liquid flow.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic section of a rotary machine (not in accordance with the invention) designed to separate particulate matter and droplets from the main gas flow,

Figure 2 is a view showing the cross section of the vanes of the intake nozzle, the row of turbine blades and the exit guide vanes of the turbine, and

Figure 3 is a schematic partial view similar to that of Figure 1 illustrating an embodiment of the invention.

The rotary machines shown in the drawings are intended for use in a bore hole of a gas well. Gas flows in the direction of the arrows 10, being drawn from the well by the action of the compressor and pumped under pressure into the bore hole. The effect of the compressor is of course to create a higher pressure at its outlet side, shown to the left in all the figures in the drawings that at its intake side.

In Figure 1, the compressor is formed by blade rows 12 on the rotor 11 and guide vanes 14 on the stator 16. The manner in which the gas is compressed is of course well known and need not be described in detail within the present context. The rotor 11 is driven by, for example, an electric motor (not shown) and each set of rotor blades and associated stationary guide vanes incrementally increases the gas pressure.

In order to separate out impurities carried in the intake gas before they can cause damage to the blades and bearings of the compressor, the compressor of Figures 1 and 2 has two sets of stationary vanes 18 and 20 on the stator 16 and a set of turbine blades 22 on the rotor 10 that precede all the compressor stages.

The guide vanes 20 acts as a nozzle that impart a significant component of swirl (i.e. a tangential component) to the gas entering at the intake end of the machine. The guide vanes 20 have an aerofoil-like section to reduce wear on their leading edges and to improve gas flow. The swirl induced by the intake nozzle has the effect of separating

out the denser impurities which move out radially and adhere to the inner wall of the stator, while the cleaner gas continues into the compressor stages. The removal of the impurities protects the bearings and blades of the compressor to improve the working life of the machine.

The swirl of the intake gases must however be removed before the gases reach the compressor stages and this is done by the turbine blades 22 which draw kinetic energy out of the swirling gases and optional further stationary guide vanes 18 that return the gases to a direction desired by the compressor. The cross sections of the blades 22 and the guide vanes 18 can once again be suitably contoured to minimise wear and improve gas flow through the rotary machine.

The effect of the turbine is to reduce the gas pressure at the first of the compressor stages. To achieve the same desired overall compression, it is therefore necessary to add a compensating compressor stage and this will increase the overall axial length of the machine.

Once the liquid and solid impurities have been separated from the gas flow, it is necessary to dispose of them in a suitable manner. Allowing them to return to the intake side of the machine is not a good solution as they will be continually recycled and they will gradually increase the level of impurities in the intake gas.

In the present invention, the inner wall of the stator 16 in the manner shown in Figure 3 with a stepped surface 30 that allows the impurities to flow from the intake side of the machine to its outlet side while adhering to the inner wall of the stator. The liquid film will be carried along the surface by the gas flow and the steps will resist any flow in the opposite direction as a result of the positive

pressure difference between the intake and outlet sides of the machine.

As the action of the compressor stages itself imparts a swirl to the gas flow, it is possible to dispense with the turbine 20,22 that precedes the compressor stages in the embodiment of Figure 1 if the stator is stepped as described above to allow the separated impurities to follow a different path through the machine from the clean gases.

It is possible for the entire inner surface to be constructed as a stepped surface being formed of a series of near conical sections 30a that are separated from one another by sharp radial shoulders 30b that prevent reverse gas and liquid flow. It is preferred, however, that a shallow stepped groove be formed in the inner wall of the stator that only extends around part of the circumference of the stator. Such a groove is more preferably arranged at the bottom of the machine so that the extraction of the separated impurities may be assisted by gravity.

CLAIMS

1. A rotary machine having blade rows that impart a high swirl component to gases flowing through the machine so that the denser liquid fraction is deflected radially outwards by centripetal action onto the inner wall of the stator of the machine and wherein a surface is provided on the inner wall of the stator of the machine along which the impurities separated by centripetal action from the gas flow are guided to flow from the gas intake side of the machine to the gas outlet side, the surface being radially stepped in such a manner as to resist reverse flow of the impurities back towards the gas intake side of the machine on account of any differential gas pressure between the intake and outlet sides of the machine.

2. A rotary machine as claimed in claim 1, wherein the guide surface is formed by a stepped groove in the inner wall of the stator that only extends around part of the circumference of the stator.

3. A rotary machine as claimed in claim 1 or 2, wherein the groove is arranged at the lower end of the stator such that separated impurities collect in the groove by the action of gravity.

4. A rotary machine constructed substantially as herein described with reference to and as illustrated in Figure 3 of the accompanying drawings.

ABSTRACT

ROTARY MACHINE

A rotary machine is described having blade rows that impart a high swirl component to gases flowing through the machine so that the denser liquid fraction is deflected radially outwards by centripetal action onto the inner wall of the stator of the machine. A surface 30a, 30b is provided on the inner wall of the stator 16 of the machine along which the impurities separated by centripetal action from the gas flow are guided to flow from the gas intake side of the machine to the gas outlet side. The surface 30a, 30b, is radially stepped in such a manner as to resist reverse flow of the impurities back towards the gas intake side of the machine on account of any differential gas pressure between the intake and outlet sides of the machine.

Figure 3.

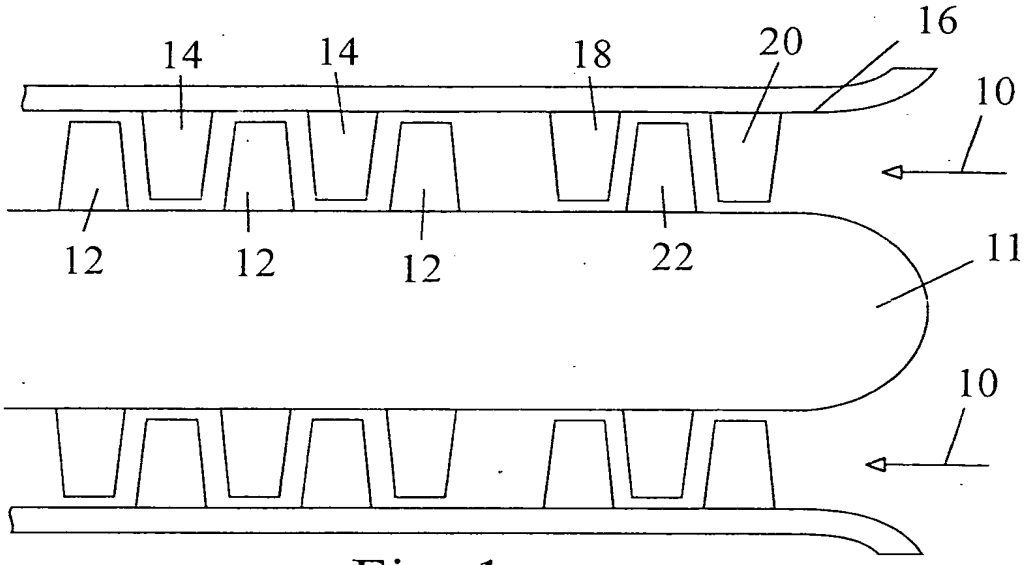

Fig. 1

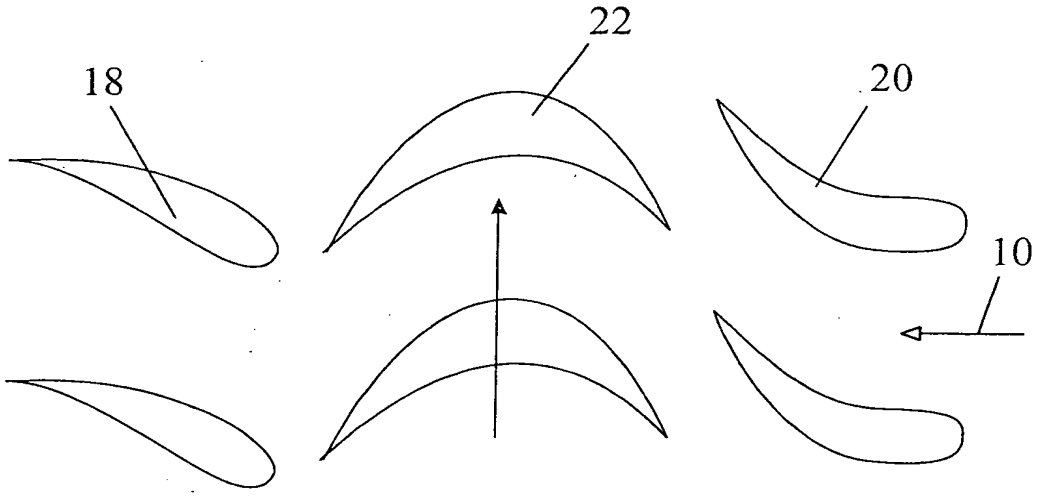

Fig. 2

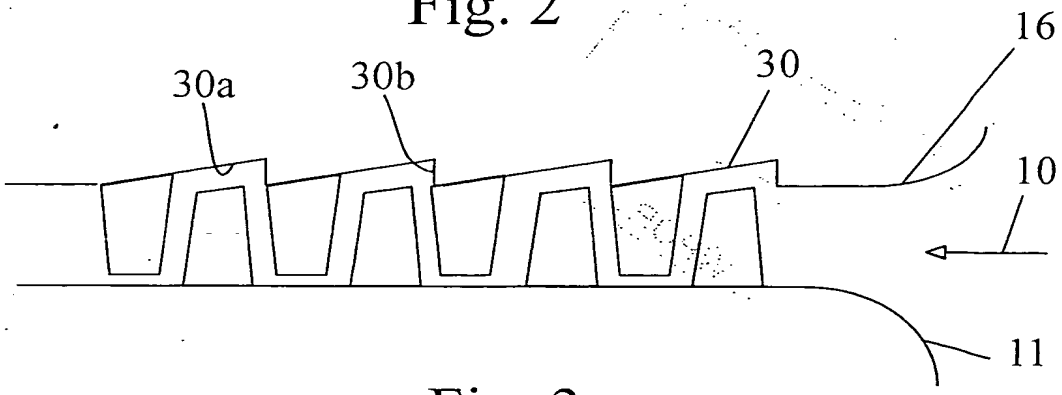

Fig. 3